Falcon2 4M, 8M, and 12M

Camera User's Manual

TELEDYNE DALSA
A Teledyne Technologies Company

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1. System Precautions and Cleaning

Precautions

Read these precautions and this manual carefully before using the camera.

Confirm that the camera's packaging is undamaged before opening it. If the packaging is damaged please contact the related logistics personnel.

Do not open the housing of the camera. The warranty is voided if the housing is opened.

Keep the camera housing temperature in a range of 10 °C to 50 °C during operation.

Do not operate the camera in the vicinity of strong electromagnetic fields. In addition, avoid electrostatic charging, violent vibration, and excess moisture.

To clean the device, avoid electrostatic charging by using a dry, clean absorbent cotton cloth dampened with a small quantity of pure alcohol. Do not use methylated alcohol. To clean the surface of the camera housing, use a soft, dry cloth. To remove severe stains use a soft cloth dampened with a small quantity of neutral detergent and then wipe dry. Do not use volatile solvents such as benzene and thinners, as they can damage the surface finish. Further cleaning instructions are below.

This camera does not support hot plugging. Power down and disconnect power to the camera before you add or replace system components.

Electrostatic Discharge and the CMOS Sensor

Image sensors and the camera bodies housing are susceptible to damage from electrostatic discharge (ESD). Electrostatic charge introduced to the sensor window surface can induce charge buildup on the underside of the window that cannot be readily dissipated by the dry nitrogen gas in the sensor package cavity. The charge normally dissipates within 24 hours and the sensor returns to normal operation.

Protecting Against Dust, Oil, and Scratches

The sensor window is part of the optical path and should be handled like other optical components, with extreme care. Dust can obscure pixels, producing dark patches on the sensor response. Dust is most visible when the illumination is collimated. The dark patches shift position as the angle of illumination changes. Dust is normally not visible when the sensor is positioned at the exit port of an integrating sphere, where the illumination is diffuse. Dust can normally be removed by blowing the window surface using an ionized air gun. Oil is usually introduced during handling. Touching the surface of the window barehanded will leave oily residues. Using rubber fingercots and rubber gloves can prevent contamination. However, the friction between rubber and the window may produce electrostatic charge that may damage the sensor. To avoid ESD damage and to avoid introducing oily residues, avoid touching the sensor. Scratches diffract incident illumination. When exposed to uniform illumination, a sensor with a scratched window will normally have brighter pixels adjacent to darker pixels. The location of these pixels will change with the angle of illumination.

Cleaning the Sensor Window

Recommended Equipment

- Glass cleaning station with microscope within clean room.
- 3M ionized air gun 980 (http:/ / solutions.3mcanada.ca/ wps/ portal/ 3M/ en_CA/ WW2/ Country/)
- Ionized air flood system, foot operated.
- Swab (HUBY-340CA-003) (http:/ / www.cleancross.net/ modules/ xfsection/ article.php?articleid=24)
- Single drop bottle (FD-2-ESD)
- E2 (Eclipse optic cleaning system (www.photosol.com)

Procedure

- Use localized ionized air flow on to the glass during sensor cleaning.
- Blow off mobile contamination using an ionized air gun.
- Place the sensor under the microscope at a magnification of 5x to determine the location of any remaining contamination.
- Clean the contamination on the sensor using one drop of E2 on a swab.
- Wipe the swab from left to right (or right to left but only in one direction). Do this in an overlapping pattern, turning the swab after the first wipe and with each subsequent wipe. Avoid swiping back and forth with the same swab in order to ensure that particles are removed and not simply transferred to a new location on the sensor window. This procedure requires you to use multiple swabs.
- Discard the swab after both sides of the swab have been used once.
- Repeat until there is no visible contamination present.

2. The Falcon2 Camera

Camera Highlights

The new Falcon2 4M, 8M, and 12M are Teledyne DALSA's new generation of area scan cameras. The cameras incorporate large resolutions and faster frame rates enabling high speed image capture with superb spatial resolution. Important features such as global shutter and improved image quality make these Falcon2 cameras the camera of choice in applications where throughput, resolution, and dynamic range matter. Global shuttering removes unwanted smear and time displacement artefacts related to rolling shutter CMOS devices. Inside these Falcon2 cameras is our latest 4, 8 and 12 megapixel CMOS sensor which has reduced dark noise levels and improved dark offset, FPN (fixed pattern noise) and PRNU (Pixel Response Non-Uniformity) levels. In addition, region of interest features will offer opportunities for higher frame rates and new applications.

The cameras are compliant with Camera Link™ specifications, delivering 8 or 10 bits of data on 8 or 10 taps (frame rates are specified at 8 bits). Further, the M42x1 thread opening allows the use of your lens of choice.

Key Features

- 12, 8 and 4 mega pixels
- Selectable 4:3 or 1:1 aspect ratios
- Global Shutter
- Exposure control
- Faster frame rates through windowing
- Good NIR response
- Built-in FPN and PRNU correction

Programmability

- Adjustable digital gain and offset
- 8 or 10 bit selectable output
- Adjustable integration time and frame rate
- Test patterns and camera diagnostics

Applications

- Automated Optical Inspection (AOI)
- 3D imaging—Laser profiling
- Semiconductor wafer inspection
- Solar panel inspection
- Electronics manufacturing
- Surface and bump inspection
- 3D solder paste inspection
- General machine vision

Models

The camera is available in the following configurations:

Table 1: Camera Models Overview

Model Number	Description
FA-80-12M1H-00-R	12M pixel monochrome Camera Link.
FA-81-12M1H-00-R	12M pixel color Camera Link.
FA-80-8M100-00-R	8M pixel monochrome Camera Link.
FA-81-8M100-00-R	8M pixel color Camera Link.
FA-80-4M180-00-R	4M pixel monochrome Camera Link.
FA-81-4M180-00-R	4M pixel color Camera Link.

Table 2: Software

Software	Product Number / Version Number
Camera firmware	Embedded within camera
GenICam™ support (XML camera description file)	Embedded within camera
Sapera LT, including CamExpert GUI application and GenICam for Camera Link imaging driver	Version 7.2 or later

Camera Performance Specifications

Table 3: Camera Performance Specifications

Specifications	Performance
Resolution	4 : 3 aspect ratio: 12M—4096 (H) x 3072 (V) 8M—3328 (H) x 2502 (V) 4M—2432 (H) x 1728 (V) 1 : 1 aspect ratio: 8M—2816 (H) x 2816 (V) 4M—2048 (H) x 2048 (V)
Pixel Rate	8 x 76 MHz or 10 x 76 MHz (8 bits only)
Max. Frame Rate	12M—58 fps / 8M—90 fps / 4M—168 fps, 10 taps*
Pixel Size	6 µm x 6 µm
Exposure Time	20 µs minimum
Bit Depth	8 bits or 10 bits
Dynamic Range	57.3 dB, typical (12M, 10 bpp**)
Output Format, Taps	8 or 10 tap interleaved
Operating Temp	0 °C to 50 °C, front plate temperature
Connectors and Mechanicals	
Data Interface	2 x Full or Extended Camera Link—SDR26
Power Connector	Hirose 12-pin circular
Power Supply	+ 12 V to + 24 V DC
Power Dissipation	9.5 W, typical
Mini-USB connector	For diagnostics only
Lens Mount	M42 x 1 (F mount optional)
Size	60 mm (H) x 60 mm (W) x 80.5 mm (D)
Mass	< 300 g
Compliance	
Regulatory Compliance	CE and RoHS

* Maximum frame rates are dependent on the aspect ratio used.

**Bits per pixel

Mono Operating Ranges	Units		Notes
Random Noise	DN rms	1.4*	Typical, FFC enabled
Broadband Responsivity	DN/ (nJ/ cm2)	See graph	
DC Offset	DN	0	FFC enabled
Antiblooming		>1000 x Saturation	
FPN	DN rms	1.1*	Typical, FFC enabled
PRNU	DN rms	2.5*	Typical, FFC enabled
Integral non-linearity	DN	< 2%	

*12M, 10 bbp, 8 taps / 10 bits Camera Link

Table 4: Frame Rates, Aspect Ratio, and Resolution Comparison

Resolution	Aspect Ratio	Maximum Column	Maximum Rows	Frame Rate 8 BPP*	Frame Rate 9 BPP*	Frame Rate 10 BPP*
12M	4:3	4096	3072	58	58	58
8M	1:1	2816	2816	90	89	66
8M	4:3	3328	2502	86	86	74
4M	1:1	2048	2048	148	122	91
4M	4:3	2432	1728	168	145	108

* Sensor bits per pixel

Certifications

Compliance
EN 55011, CISPR 11, EN 55022, CISPR 22, FCC Part 15, and ICES-003 Class A Emissions Requirements. EN 55024, and EN 61326-1 Immunity to Disturbance.

Supported Industry Standards

GenICam™

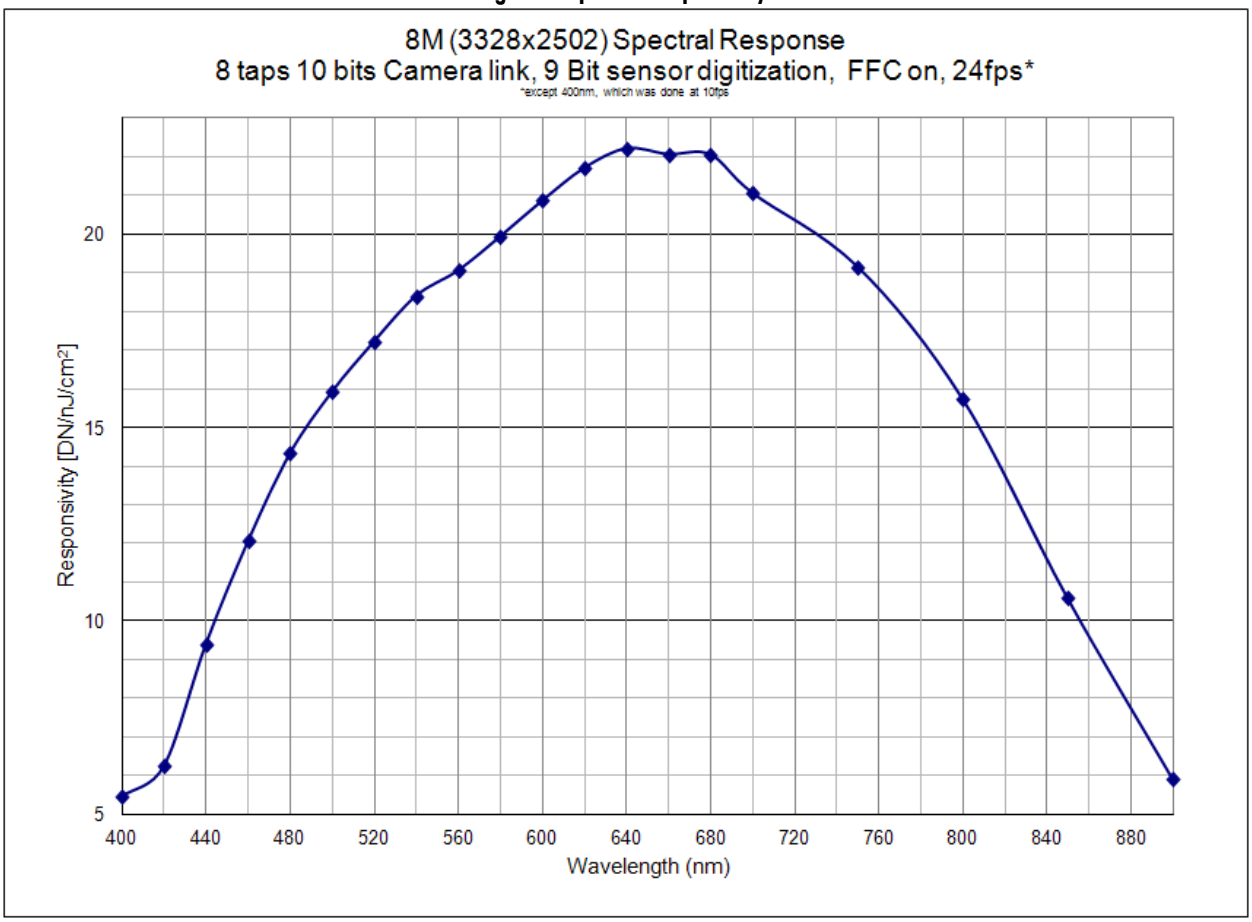
Falcon2 cameras implement a superset of the GenICam™ specification which defines device capabilities. This description takes the form of an XML device description file respecting the syntax defined by the GenApi module of the GenICam™ specification. For more information see www.genicam.org.

Responsivity

The responsivity graph describes the sensor response to different wavelengths of light (excluding lens and light source characteristics).

The quantum efficiency (QE) graph describes the fraction of photons at each wavelength that contribute charge to the pixel.

Figure 1: Spectral Responsivity



Sensor Cosmetic Specifications

The following table lists the current cosmetic specifications for the Teledyne DALSA sensor used in the Falcon2 series.

Table 5: Sensor Cosmetic Specifications

Feature / Specification	Unit	MIN	TYP	MAX	Notes
Dark Pixel Definition - absolute output level	DN			> 500	4 frame average
Dark Pixel Count	max #/ die			50	
Light Pixel Definition - deviates from frame average	%			± 30	4 frame average image for scene & dark correction
Average Frame Output Level	% SAT	40	50	60	illuminated with diffused light source on production tester
Tolerated Count	max #/ die			50	
Die Cluster Defect Definition	defects/ kernel	2 / 3x3		≤ 5 / 3x3	
Detection Threshold	-		Groups of dark and light pixels		combined dark & light pixel defects
Tolerated Count	max #/ die			7	based on estimation algorithm in production tester
Die Spot Defect Definition	defects/ kernel	6 / 3x3			
Detection Threshold			Groups of dark and light pixels		combined dark & light pixel defects
Tolerated Count	max #/ die	-		0	
Glass Spot Defect Definition	defects/ kernel	8 / 3x3		8 / 3x3	illuminated with aperture (collimated) light source on production tester
Detection Threshold	% of ave.			± 8	4 frame average - any pixel outside +/ - 8% of average
Tolerated Count	max #/ die			1	1 spot of 9 pixels allowed; no limit on spots below 9 pixels
Column Defect Definition	defects/ kernel			> 8 / 1x12	
Column Defect Count	max #/ die			0	
Row Defect Definition	defects/ kernel			> 8 / 12x1	
Row Defect Count	max #/ die			0	

Definition of Blemishes
Dark pixel defect: Pixel whose signal, in dark, exceeds 500 DN.
Light pixel defect: Pixel whose signal, at nominal light (illumination at 50% of the linear range), deviates more than ±30% from its neighboring pixels.
Cluster defect: A grouping of at most 2 to 5 pixel defects within a sub-area of 3*3 pixels.
Die Spot defect: A grouping of 6 or more pixel defects within a sub-area of 3*3 pixels.
Glass Spot defect: A grouping of 9 pixel defects within a sub-area of 3*3 pixels.
Column defect: A column that has more than 8 defect pixels in a 1*12 kernel.
Row defect: A row that has more than 8 defects in a 12*1 kernel.
Test conditions Temperature: 40°C.
Integration Time: 12ms.

Sensor Block Diagram and Pixel Readout

Figure 2: 8 Tap Camera Link Configuration Sensor Block Diagram. Aspect Ratio 4 : 3.

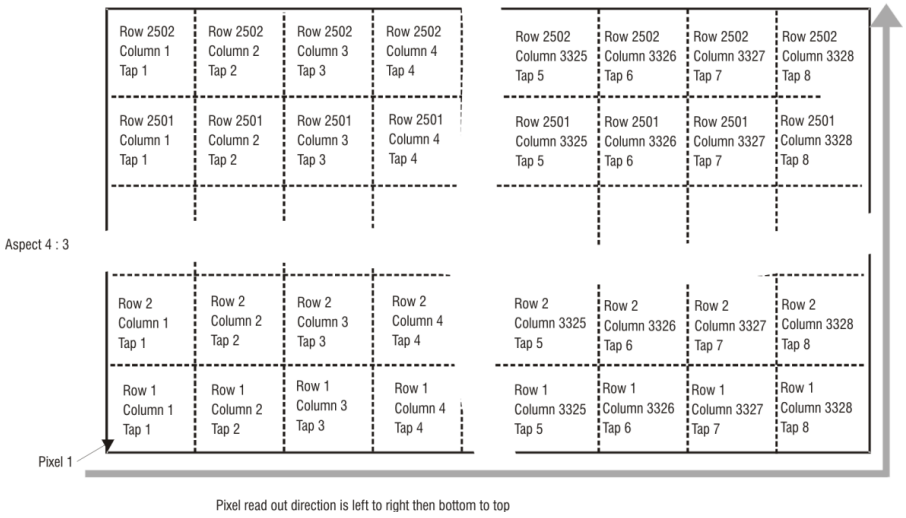
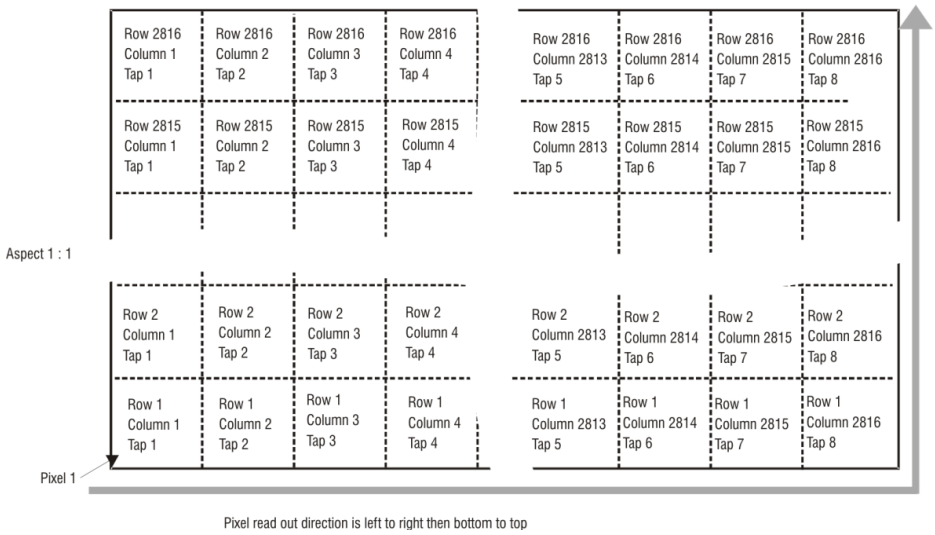

Row 2502 Column 1 Tap 1
Row 2502 Column 2 Tap 2
Row 2502 Column 3 Tap 3
Row 2502 Column 4 Tap 4
Row 2502 Column 3325 Tap 5
Row 2502 Column 3326 Tap 6
Row 2502 Column 3327 Tap 7
Row 2502 Column 3328 Tap 8
Row 2501 Column 1 Tap 1
Row 2501 Column 2 Tap 2
Row 2501 Column 3 Tap 3
Row 2501 Column 4 Tap 4
Row 2501 Column 3325 Tap 5
Row 2501 Column 3326 Tap 6
Row 2501 Column 3327 Tap 7
Row 2501 Column 3328 Tap 8
Aspect 4 : 3
Row 2 Column 1 Tap 1
Row 2 Column 2 Tap 2
Row 2 Column 3 Tap 3
Row 2 Column 4 Tap 4
Row 2 Column 3325 Tap 5
Row 2 Column 3326 Tap 6
Row 2 Column 3327 Tap 7
Row 2 Column 3328 Tap 8
Row 1 Column 1 Tap 1
Row 1 Column 2 Tap 2
Row 1 Column 3 Tap 3
Row 1 Column 4 Tap 4
Row 1 Column 3325 Tap 5
Row 1 Column 3326 Tap 6
Row 1 Column 3327 Tap 7
Row 1 Column 3328 Tap 8
Pixel 1
Pixel read out direction is left to right then bottom to top

Figure 3: 8 Tap Camera Link Configuration Sensor Block Diagram. Aspect Ratio 1 : 1.


Row 2816 Column 1 Tap 1
Row 2816 Column 2 Tap 2
Row 2816 Column 3 Tap 3
Row 2816 Column 4 Tap 4
Row 2816 Column 2813 Tap 5
Row 2816 Column 2814 Tap 6
Row 2816 Column 2815 Tap 7
Row 2816 Column 2816 Tap 8
Row 2815 Column 1 Tap 1
Row 2815 Column 2 Tap 2
Row 2815 Column 3 Tap 3
Row 2815 Column 4 Tap 4
Row 2815 Column 2813 Tap 5
Row 2815 Column 2814 Tap 6
Row 2815 Column 2815 Tap 7
Row 2815 Column 2816 Tap 8
Aspect 1 : 1
Row 2 Column 1 Tap 1
Row 2 Column 2 Tap 2
Row 2 Column 3 Tap 3
Row 2 Column 4 Tap 4
Row 2 Column 2813 Tap 5
Row 2 Column 2814 Tap 6
Row 2 Column 2815 Tap 7
Row 2 Column 2816 Tap 8
Row 1 Column 1 Tap 1
Row 1 Column 2 Tap 2
Row 1 Column 3 Tap 3
Row 1 Column 4 Tap 4
Row 1 Column 2813 Tap 5
Row 1 Column 2814 Tap 6
Row 1 Column 2815 Tap 7
Row 1 Column 2816 Tap 8
Pixel 1
Pixel read out direction is left to right then bottom to top

Note: As viewed from the front of the camera without lens.

Mechanicals

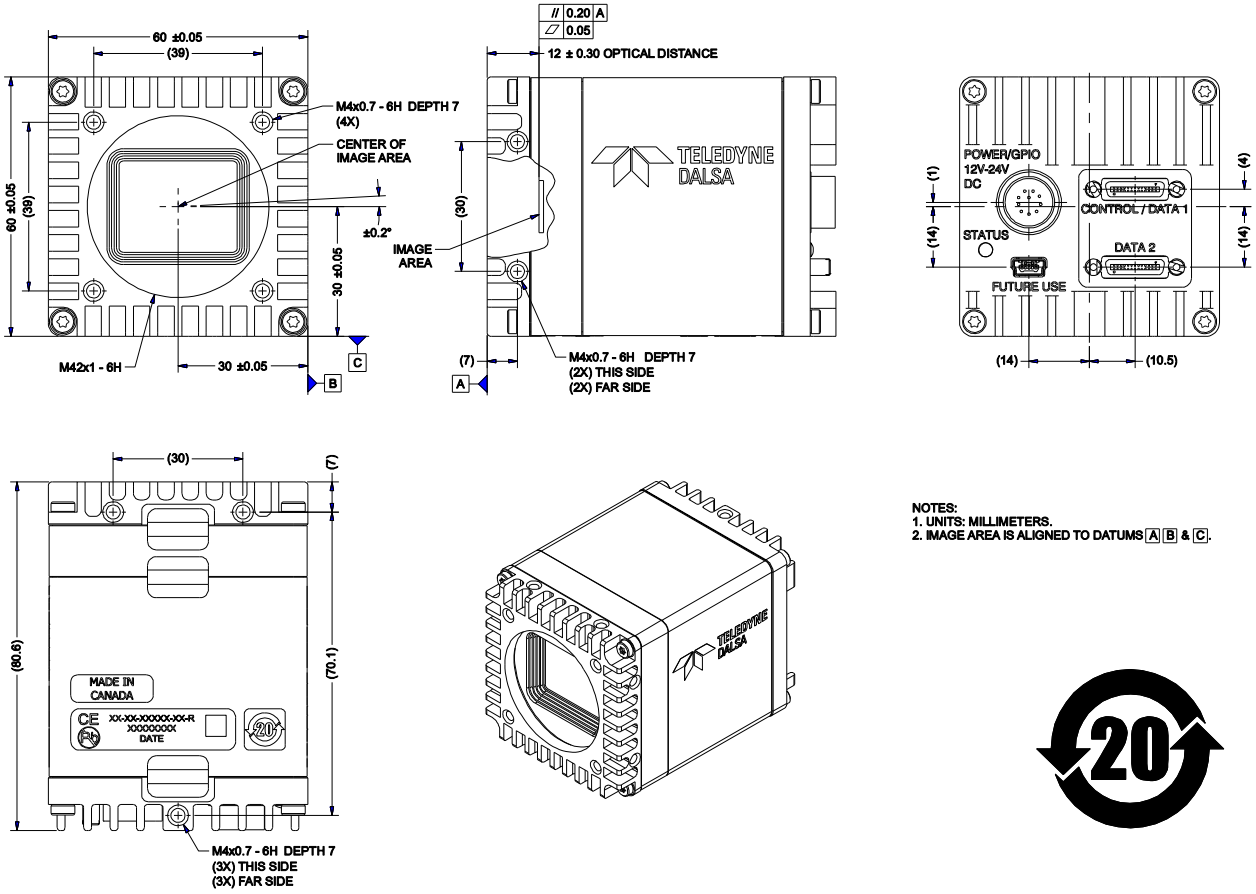


Figure 4: Camera Mechanical

3. Software and Hardware Setup

Minimum System Requirements

To achieve best system performance, the following minimum requirements are recommended:

- High bandwidth frame grabber recommended, e.g. DALSA PX8 Full Camera link frame grabber (Part # OR-X8CO-XPF00).
- PCI x8 slot.
- Operating system: Windows XP 32-bit.

Setup Steps: Overview

Take the following steps in order to setup and run your camera system. They are described briefly below and in more detail in the sections that follow.

1. Install and Configure Frame Grabber, Graphics Card, and GUI

If your host computer does not have a PX8 full Camera link frame grabber and supporting PCIe x8 graphics card installed, then you need to install them.

We recommend the X64 Xcelera-CL PX8 frame grabber or equivalent, described in detail on the teledynedalsa.com site here. Follow the manufacturer's installation instructions.

A GenICam™ compliant XML device description file is embedded within the Falcon2 firmware allowing GenICam™ compliant application to know the camera's capabilities immediately after connection. Installing SaperaLT gives you access to the CamExpert GUI, a GenICam™ compliant application.

2. Connect Power and Camera Link Cables

- Connect a power cable from the camera to a +12 VDC to +24 VDC (±5%) power supply. Note: 11.6 V minimum.
- Connect the Camera link cables from the camera to the computer.

3. Establish communicating with the camera

Start the GUI and establish communication with the camera. Refer to page 17 for a description on communicating with the camera.

4. Check camera LED, settings and test pattern

Ensure the camera is operating properly by checking the LED, the current, active settings, and by acquiring a test pattern.

5. Operate the Camera

At this point you will be ready to start operating the camera in order to acquire images, set camera functions, and save settings.

Step 1. Install and configure the frame grabber, graphics card and GUI

Install Frame Grabber

Install a PX8 full Camera link frame grabber according to the manufacturer's description.

We recommend the X64 Xcelera-CL PX8 frame grabber or equivalent, described in detail on the teledynedalsa.com site here.

Install Graphics Card

PCIe x8 graphics card supports the frame grabber. Follow the manufacturer's installation instructions.

Install Sapera LT and CamExpert

Communicate with the camera using a Camera Link-compliant interface. We recommend you use CamExpert. CamExpert is the camera interfacing tool supported by the Sapera library and comes bundled with SaperaLT. Using CamExpert is the simplest and quickest way to send commands to and receive information from the camera.

Camera link Environment
These cameras implement the Camera link specification, which defines the device capabilities.
The Camera link XML device description file is embedded within the camera firmware allowing Camera link-compliant applications to recognize the cameras' capabilities immediately after connection.

Step 2. Connect Power, Data, and Trigger Cables

Note: the use of cables types and lengths other than those specified may result in increased emission or decreased immunity and performance of the camera.

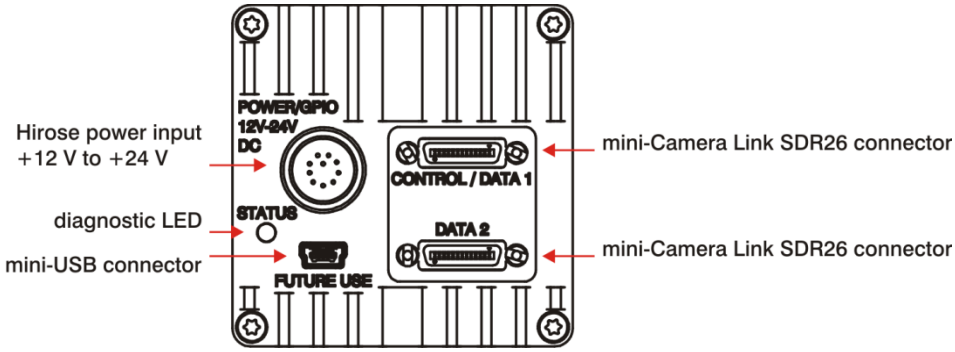


Figure 5: Input and Output, trigger, and Power Connectors

WARNING! Grounding Instructions
Static electricity can damage electronic components. It's critical that you discharge any static electrical charge by touching a grounded surface, such as the metal computer chassis, before performing handling the camera hardware.

Power Connector

WARNING: It is extremely important that you apply the appropriate voltages to your camera. Incorrect voltages may damage the camera. Input voltage requirement: +12 VDC to +24 VDC (± 5 %), 2 Amps, 11.6 V minimum. Before connecting power to the camera, test all power supplies.

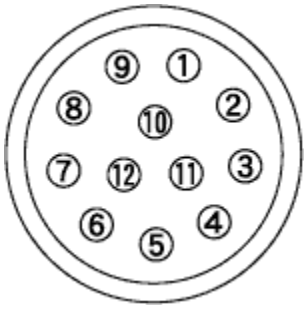


Figure 6: 12-pin Hirose Circular Male Power Plug—Power Connector

Table 6. Power Plug Pinout

Pin	Description	Pin	Description
1	GND	7	OUT1_C1/ Strobe_C1
2	+12 V to +24 V DC	8	OUT1_C0/ Strobe_C0
3	OUT0_C0	9	GND
4	OUT0_C1	10	+12 V to +24 V DC
5	IN0-	11	IN1+/ Trigger
6	IN0+	12	IN1-/ Trigger

WARNING: When setting up the camera's power supplies follow these guidelines:

- Apply the appropriate voltages.
- Protect the camera with a 2 amp slow-blow fuse between the power supply and the camera.
- Do not use the shield on a multi-conductor cable for ground.
- Keep leads as short as possible in order to reduce voltage drop.
- Use high-quality linear supplies in order to minimize noise.

Note: If your power supply does not meet these requirements, then the camera performance specifications are not guaranteed.

LEDs

The camera is equipped with an LED on the back to display the operational status of the camera. The table below summarizes the operating states of the camera and the corresponding LED states. When more than one condition is active, the LED indicates the condition with the highest priority.

Color of Status LED	Meaning
Off	No power or hardware malfunction
Red solid	Warning (e.g. temperature)
Red solid	Fatal error state
Blue solid	Upgrading internal firmware.
Blue slow blinking	Camera waiting for warm up to complete
Blue solid	At initial power up and when acquisition is disabled. This happens when changing a camera feature that effects the image output (e.g. aoi, bit depth, etc.)
Green solid	Free-running acquisition

Data Connector: Camera Link

The camera uses two mini-Camera Link SDR-26 cables transmitting the Camera Link Full or Extended configuration. The figure below shows the SDR-26 mini Camera Link Connector and the tables that follow list the Camera Link Full and Extended configurations.

For detailed information on Camera Link please refer to the Camera Link Road Map available from the Knowledge Center on the Teledyne DALSA Web site:

(http:/ / www.teledynedalsa.com/ mv/ knowledge/ appnotes.aspx).

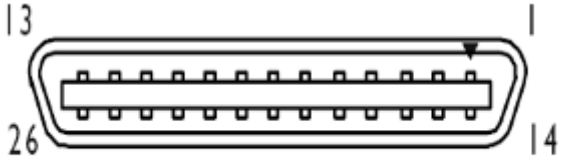


Figure 7. SDR-26 Mini Camera Link Connector

Data 2			Control / Data 1		
Camera Connector	**Right Angle Frame Grabber Connector**	**Channel Link Signal**	**Camera Connector**	**Right Angle Frame Grabber Connector**	**Channel Link Signal**
1	1	inner shield	1	1	inner shield
14	14	inner shield	14	14	inner shield
2	25	Y0-	2	25	X0-
15	12	Y0+	15	12	X0+
3	24	Y1-	3	24	X1-
16	11	Y1+	16	11	X1+
4	23	Y2-	4	23	X2-
17	10	Y2+	17	10	X2+
5	22	Yclk-	5	22	Xclk-
18	9	Yclk+	18	9	Xclk+
6	21	Y3-	6	21	X3-
19	8	Y3+	19	8	X3+
7	20	100 ohm	7	20	SerTC+
20	7	terminated	20	7	SerTC-
8	19	Z0-	8	19	SerTFG-
21	6	Z0+	21	6	SerTFG+
9	18	Z1-	9	18	CC1-
22	5	Z1+	22	5	CC1+
10	17	Z2-	10	17	CC2+
23	4	Z2+	23	4	CC2-
11	16	Zclk-	11	16	CC3-
24	3	Zclk+	24	3	CC3+
12	15	Z3-	12	15	CC4+
25	2	Z3+	25	2	CC4-
13	13	inner shield	13	13	inner shield
26	26	inner shield	26	26	inner shield

*Exterior Overshield is connected to the shells of the connectors on both ends. Unused pairs should be terminated in 100 ohms at both ends of the cable. Inner shield is connected to signal ground inside camera

Full Configuration

8 taps 8 bits Camera link Full configuration

Connector 1: Channel link X		Connector 2: Channel link Y		Connector 3: Channel link Z	
Camera/Frame Grabber Pin	Bit Name	Camera/Frame Grabber Pin	Bit Name	Camera/Frame Grabber Pin	Bit Name
Tx0/Rx0	D0(0)	Tx0/Rx0	D3(0)	Tx0/Rx0	D6(0)
Tx1/Rx1	D0(1)	Tx1/Rx1	D3(1)	Tx1/Rx1	D6(1)
Tx2/Rx2	D0(2)	Tx2/Rx2	D3(2)	Tx2/Rx2	D6(2)
Tx3/Rx3	D0(3)	Tx3/Rx3	D3(3)	Tx3/Rx3	D6(3)
Tx4/Rx4	D0(4)	Tx4/Rx4	D3(4)	Tx4/Rx4	D6(4)
Tx5/Rx5	D0(7)	Tx5/Rx5	D3(7)	Tx5/Rx5	D6(7)
Tx6/Rx6	D0(5)	Tx6/Rx6	D3(5)	Tx6/Rx6	D6(5)
Tx7/Rx7	D1(0)	Tx7/Rx7	D4(0)	Tx7/Rx7	D7(0)
Tx8/Rx8	D1(1)	Tx8/Rx8	D4(1)	Tx8/Rx8	D7(1)
Tx9/Rx9	D1(2)	Tx9/Rx9	D4(2)	Tx9/Rx9	D7(2)
Tx10/Rx10	D1(6)	Tx10/Rx10	D4(6)	Tx10/Rx10	D7(6)
Tx11/Rx11	D1(7)	Tx11/Rx11	D4(7)	Tx11/Rx11	D7(7)
Tx12/Rx12	D1(3)	Tx12/Rx12	D4(3)	Tx12/Rx12	D7(3)
Tx13/Rx13	D1(4)	Tx13/Rx13	D4(4)	Tx13/Rx13	D7(4)
Tx14/Rx14	D1(5)	Tx14/Rx14	D4(5)	Tx14/Rx14	D7(5)
Tx15/Rx15	D2(0)	Tx15/Rx15	D5(0)	Tx15/Rx15	Not Used
Tx16/Rx16	D2(6)	Tx16/Rx16	D5(6)	Tx16/Rx16	Not Used
Tx17/Rx17	D2(7)	Tx17/Rx17	D5(7)	Tx17/Rx17	Not Used
Tx18/Rx18	D2(1)	Tx18/Rx18	D5(1)	Tx18/Rx18	Not Used
Tx19/Rx19	D2(2)	Tx19/Rx19	D5(2)	Tx19/Rx19	Not Used
Tx20/Rx20	D2(3)	Tx20/Rx20	D5(3)	Tx20/Rx20	Not Used
Tx21/Rx21	D2(4)	Tx21/Rx21	D5(4)	Tx21/Rx21	Not Used
Tx22/Rx22	D2(5)	Tx22/Rx22	D5(5)	Tx22/Rx22	Not Used
Tx23/Rx23	Not Used	Tx23/Rx23	Not Used	Tx23/Rx23	Not Used
Tx24/Rx24	LVAL	Tx24/Rx24	LVAL	Tx24/Rx24	LVAL
Tx25/Rx25	FVAL	Tx25/Rx25	FVAL	Tx25/Rx25	FVAL
Tx26/Rx26	Not Used	Tx26/Rx26	Not Used	Tx26/Rx26	Not Used
Tx27/Rx27	D0(6)	Tx27/Rx27	D3(6)	Tx27/Rx27	D6(6)

Tap 1 bits are D0(x)...Tap 8 bits are D7(x)

Extended Configurations

10 taps 8 bits Camera link Extended configuration

Connector 1: Channel link X		Connector 1: Channel link Y		Connector 1: Channel link Z	
Camera/Frame Grabber Pin	Bit Name	Camera/Frame Grabber Pin	Bit Name	Camera/Frame Grabber Pin	Bit Name
Tx0/Rx0	D0(0)	Tx0/Rx0	D3(2)	Tx0/Rx0	D6(5)
Tx1/Rx1	D0(1)	Tx1/Rx1	D3(3)	Tx1/Rx1	D6(6)
Tx2/Rx2	D0(2)	Tx2/Rx2	D3(4)	Tx2/Rx2	D6(7)
Tx3/Rx3	D0(3)	Tx3/Rx3	D3(5)	Tx3/Rx3	D7(0)
Tx4/Rx4	D0(4)	Tx4/Rx4	D3(6)	Tx4/Rx4	D7(1)
Tx5/Rx5	D0(5)	Tx5/Rx5	D3(7)	Tx5/Rx5	D7(2)
Tx6/Rx6	D0(6)	Tx6/Rx6	D4(0)	Tx6/Rx6	D7(3)
Tx7/Rx7	D0(7)	Tx7/Rx7	D4(1)	Tx7/Rx7	D7(4)
Tx8/Rx8	D1(0)	Tx8/Rx8	D4(2)	Tx8/Rx8	D7(5)
Tx9/Rx9	D1(1)	Tx9/Rx9	D4(3)	Tx9/Rx9	D7(6)
Tx10/Rx10	D1(2)	Tx10/Rx10	D4(4)	Tx10/Rx10	D7(7)
Tx11/Rx11	D1(3)	Tx11/Rx11	D4(5)	Tx11/Rx11	D8(0)
Tx12/Rx12	D1(4)	Tx12/Rx12	D4(6)	Tx12/Rx12	D8(1)
Tx13/Rx13	D1(5)	Tx13/Rx13	D4(7)	Tx13/Rx13	D8(2)
Tx14/Rx14	D1(6)	Tx14/Rx14	D5(0)	Tx14/Rx14	D8(3)
Tx15/Rx15	D1(7)	Tx15/Rx15	D5(1)	Tx15/Rx15	D8(4)
Tx16/Rx16	D2(0)	Tx16/Rx16	D5(2)	Tx16/Rx16	D8(5)
Tx17/Rx17	D2(1)	Tx17/Rx17	D5(3)	Tx17/Rx17	D8(6)
Tx18/Rx18	D2(2)	Tx18/Rx18	D5(4)	Tx18/Rx18	D8(7)
Tx19/Rx19	D2(3)	Tx19/Rx19	D5(5)	Tx19/Rx19	D9(0)
Tx20/Rx20	D2(4)	Tx20/Rx20	D5(6)	Tx20/Rx20	D9(1)
Tx21/Rx21	D2(5)	Tx21/Rx21	D5(7)	Tx21/Rx21	D9(2)
Tx22/Rx22	D2(6)	Tx22/Rx22	D6(0)	Tx22/Rx22	D9(3)
Tx23/Rx23	D2(7)	Tx23/Rx23	D6(1)	Tx23/Rx23	D9(4)
Tx24/Rx24	LVAL	Tx24/Rx24	D6(2)	Tx24/Rx24	D9(5)
Tx25/Rx25	FVAL	Tx25/Rx25	D6(3)	Tx25/Rx25	D9(6)
Tx26/Rx26	D3(0)	Tx26/Rx26	D6(4)	Tx26/Rx26	D9(7)
Tx27/Rx27	D3(1)	Tx27/Rx27	LVAL	Tx27/Rx27	LVAL

8 taps 10 bits Camera link Extended configuration

Connector 1: Channel link X		Connector 1: Channel link Y		Connector 1: Channel link Z	
Camera/Frame Grabber Pin	Bit Name	Camera/Frame Grabber Pin	Bit Name	Camera/Frame Grabber Pin	Bit Name
Tx0/Rx0	D0(2)	Tx0/Rx0	D3(2)	Tx0/Rx0	D6(2)
Tx1/Rx1	D0(3)	Tx1/Rx1	D3(3)	Tx1/Rx1	D6(3)
Tx2/Rx2	D0(4)	Tx2/Rx2	D3(4)	Tx2/Rx2	D6(4)
Tx3/Rx3	D0(5)	Tx3/Rx3	D3(5)	Tx3/Rx3	D6(5)
Tx4/Rx4	D0(6)	Tx4/Rx4	D3(6)	Tx4/Rx4	D6(6)
Tx5/Rx5	D0(9)	Tx5/Rx5	D3(9)	Tx5/Rx5	D6(9)
Tx6/Rx6	D0(7)	Tx6/Rx6	D3(7)	Tx6/Rx6	D6(7)
Tx7/Rx7	D1(2)	Tx7/Rx7	D4(2)	Tx7/Rx7	D7(2)
Tx8/Rx8	D1(3)	Tx8/Rx8	D4(3)	Tx8/Rx8	D7(3)
Tx9/Rx9	D1(4)	Tx9/Rx9	D4(4)	Tx9/Rx9	D7(4)
Tx10/Rx10	D1(8)	Tx10/Rx10	D4(8)	Tx10/Rx10	D7(8)
Tx11/Rx11	D1(9)	Tx11/Rx11	D4(9)	Tx11/Rx11	D7(9)
Tx12/Rx12	D1(5)	Tx12/Rx12	D4(5)	Tx12/Rx12	D7(5)
Tx13/Rx13	D1(6)	Tx13/Rx13	D4(6)	Tx13/Rx13	D7(6)
Tx14/Rx14	D1(7)	Tx14/Rx14	D4(7)	Tx14/Rx14	D7(7)
Tx15/Rx15	D2(2)	Tx15/Rx15	D5(2)	Tx15/Rx15	D2(1)
Tx16/Rx16	D2(8)	Tx16/Rx16	D5(8)	Tx16/Rx16	D5(1)
Tx17/Rx17	D2(9)	Tx17/Rx17	D5(9)	Tx17/Rx17	D6(0)
Tx18/Rx18	D2(3)	Tx18/Rx18	D5(3)	Tx18/Rx18	D3(0)
Tx19/Rx19	D2(4)	Tx19/Rx19	D5(4)	Tx19/Rx19	D3(1)
Tx20/Rx20	D2(5)	Tx20/Rx20	D5(5)	Tx20/Rx20	D4(0)
Tx21/Rx21	D2(6)	Tx21/Rx21	D5(6)	Tx21/Rx21	D4(1)
Tx22/Rx22	D2(7)	Tx22/Rx22	D5(7)	Tx22/Rx22	D5(0)
Tx23/Rx23	D0(1)	Tx23/Rx23	D2(0)	Tx23/Rx23	D7(1)
Tx24/Rx24	LVAL	Tx24/Rx24	LVAL	Tx24/Rx24	LVAL
Tx25/Rx25	FVAL	Tx25/Rx25	D1(0)	Tx25/Rx25	D6(1)
Tx26/Rx26	D0(0)	Tx26/Rx26	D1(1)	Tx26/Rx26	D7(0)
Tx27/Rx27	D0(8)	Tx27/Rx27	D3(8)	Tx27/Rx27	D6(8)

Camera Link cable quality and length

The maximum allowable Camera Link cable length depends on the quality of the cable used and the Camera Link strobe frequency. Cable quality degrades over time as the cable is flexed. In addition, as the Camera Link strobe frequency is increased the maximum allowable cable length will decrease.

The Falcon2 cameras are capable of driving cables less than 7 metres in length. We do not guarantee good imaging performance with low quality cables of *any* length. In general, we recommend the use of high quality cables in lengths for any cable length.

Recommended Cables

We recommend the use of high-quality mini-CL cables. Teledyne DALSA has 3 meter and 5 meter cables available as accessories. Contact Customer Support.

Input Signals, Camera Link

The camera accepts control inputs through the mini-Camera Link SDR-26F connector. The camera ships in internal sync, and internally programmed integration.

EXSYNC (Frame Readout Trigger)

Frame rate can be set internally using the serial interface. The external control signal EXSYNC is optional and enabled through the serial interface. This camera uses the falling edge of EXSYNC to trigger pixel readout.

The EXSYNC signal tells the camera when to integrate and readout the image. It can be either an internally generated signal by the camera, or it can be supplied externally via the serial interface. Depending upon the mode of operation the high time of the EXSYNC signal can represent the integration period.

Output Signals, Camera Link Clocking Signals

These signals indicate when data is valid, allowing you to clock the data from the camera to your acquisition system. These signals are part of the Camera Link configuration and you should refer to the Camera Link Implementation Road Map, available at our Knowledge Center, for the standard location of these signals.

Clocking Signal	Indicates
LVAL (high)	Outputting valid line
DVAL	Not used, stuck low
STROBE (rising edge)	Valid data
FVAL (high)	Outputting valid frame

- The sensor internally digitizes to 10, 9, or 8 bits. The camera outputs the 8 most significant bits (MSB's) or all 10-bits depending on the Camera Link mode that the camera is operating in.

Step 3. Establish Communication with the Camera

Power on the camera

Turn on the camera's power supply. You may have to wait up to 60 seconds while the camera warms up and prepares itself for operation. The camera must boot fully before it will be recognized by the GUI—the LED turns green once the camera is ready.

Communicate with the camera using two CamExpert windows: one to communicate with the frame grabber and one to communicate with the camera.

Connect to the frame grabber

1. Start Sapera CamExpert (or equivalent Camera Link compliant interface) by double clicking the desktop icon created during the software installation.
2. CamExpert will search for installed Sapera devices. In the Devices list area on the left side, the connected frame grabber will be shown.
3. Select the frame grabber device by clicking on the name.

Connect to the camera

1. Start a new Sapera CamExpert application (or equivalent Camera Link compliant interface) by double clicking the desktop icon created during the software installation.
2. CamExpert will search for installed Sapera devices. In the Devices list area on the left side, the connected Falcon2 camera will be shown.
3. Select the Falcon2 camera device by clicking on the camera user-defined name. By default the camera is identified by its serial number.

Check LED Status

If the camera is operating correctly at this point, the diagnostic LED will flash blue for approximately 10 seconds and then turn solid green.

Software Interface

All the camera features can be controlled through the CamExpert interface. For example, under the Sensor Control menu in the camera window you can control the frame rate and exposure times.

Note: the camera uses two CamExpert interfaces to send commands and display the results. One window controls the camera and one displays the output received from the frame grabber.

Also Note: If CamExpert is running during a camera reset operation, then you will have to reload the GUI window used to control the camera once the camera is powered up again. Do this by either 1) closing and reopening the CamExpert window, or 2) by going to "Image Viewer" in the "Device" tab and selecting the camera again.

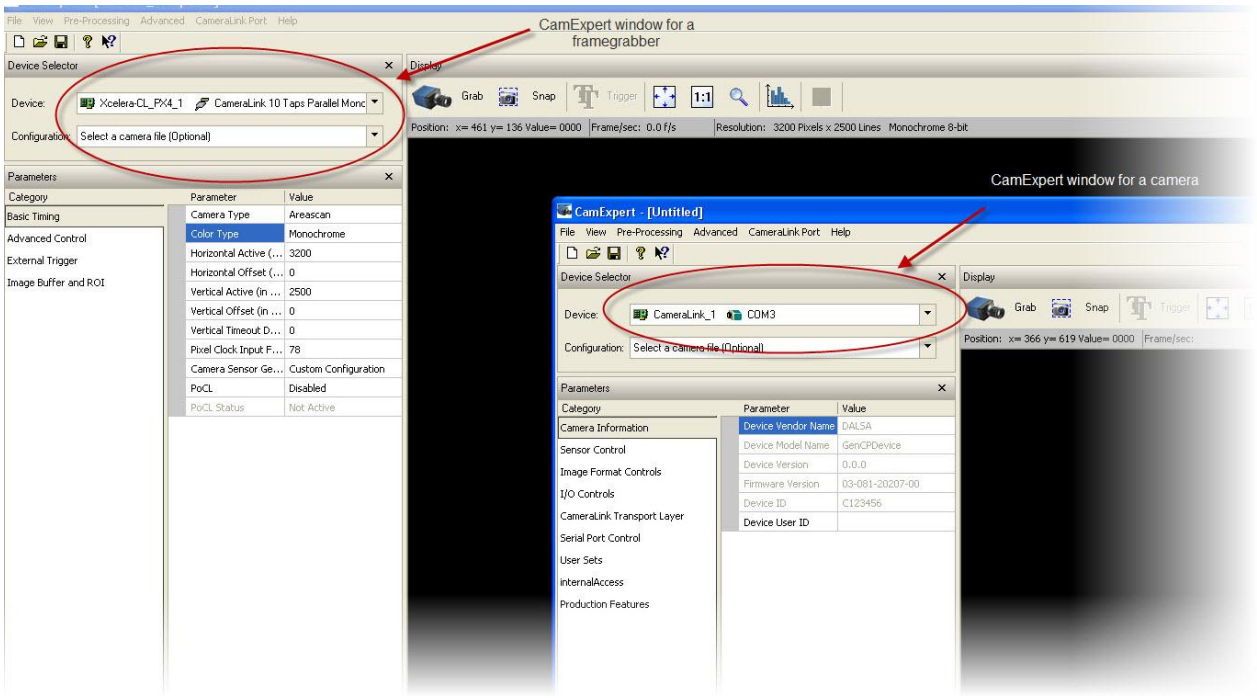


Figure 8. Two CamExpert window shown. One connected to the frame grabber and one to the camera.

At this point your host and camera system should be setup and you can verify the camera's operation by retrieving a test pattern and setting the camera's trigger and exposure time.

Note that within the CamExpert window that controls the camera, the image display and associated buttons such as Grab and Snap are inactive and have no function.

Step 4. Check Camera Test Patterns and Set Trigger and Exposure Time

Review a Test Image

The camera is now ready to retrieve a test pattern. Select **Image Format Control > Test Image Selector** and choose one of the following available test images:

Grey Horizontal Ramp
Grey Vertical Ramp
Purity
Diagonal Ramp
FPN Diagonal Ramp
PRNU
Sensor Static Pattern1
Sensor Dynamic Pattern1
Static Value

At this point you are ready to start operating the camera in order to acquire images, set camera functions, and save settings.

4. Camera Operation

Factory Settings

The camera ships and powers up for the first time with the following factory settings:

- Flat field coefficients enabled (calibrated in internal exposure mode, non-concurrent readout and integration).
- Internal exposure mode (internal frame rate and exposure time).
- Maximum frame rate and exposure time.
- Extended Camera Link mode 10 taps, 8 bits, 76 MHz pixel rate.
- 4 : 3 aspect ratio.

Check Camera and Sensor Information

Camera and sensor information can be retrieved via a controlling application—in the examples shown here, CamExpert. Parameters such as camera model, firmware version, sensor characteristics, etc. are read to uniquely identify the connected device.

The camera information parameters are grouped together as members of the Camera Information set.

Camera Information	
Parameter	**Options**
Vendor Name	
Model Name	
Camera Version	**Read Only Parameters**
Firmware Version	
Camera serial ID number	
Temperature Selector	Select the location at which to measure the camera's temperature—either at the sensor board or at the main board (processing board). Toggle between boards to update temperature. In general, the temperature at the sensor board is 20 °C greater than the temperature at the front plate. The temperature of the sensor board should not exceed 70 °C.
Camera temperature in °C	Displays temperature.
User ID	User defined camera name up to 64 characters

Saving and Restoring Camera Settings

The parameters used to select, load and save user sets are grouped together under the Camera Information set of features.

Camera Information	
Parameter	**Choices**
User Set Default Selector	Select the camera parameters to load when the camera is reset or powered up as the Factory set, or as User Set 1, 2, 3, or 4. Selecting the set from the list automatically saves it as the default set.
User Set Selector	Select the Factory, User, or FFC set to Save or Load. Factory Set User Set 1, 2, 3, 4
User Set Load	Load the set specified by User Set Selector to the camera and make it the active / current set.
User Set Save	Save the current set as selected user set.

Description of the Camera Settings

The camera operates in one of three settings:

1. Current session.
2. User setting.
3. Factory setting (read-only).
4. Default setting.

The current settings can be saved (thereby becoming the user setting) using the User Set Save parameter. A previously saved user setting (User Set 1 to 4) or the factory settings can be restored using the User Set Selector and User Set Load parameters.

Either the Factory or one of the User settings can be saved as the Default Setting by selecting the set in the User Set Default Selector. The chosen set automatically saves as the default setting and is the set loaded when the camera is reset or powered up.

The relationship between these three settings is illustrated in Figure 9. Relationship between the Camera Settings:

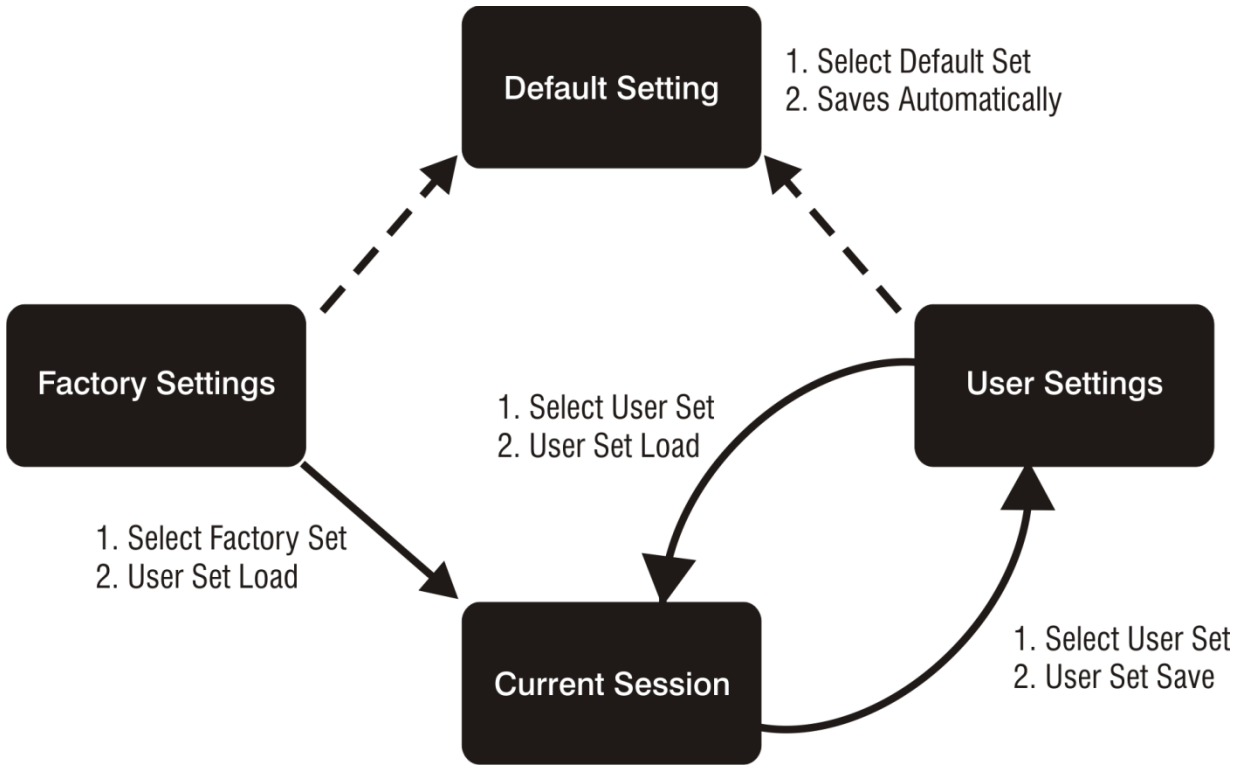


Figure 9. Relationship between the Camera Settings

Active Settings for Current Session

The active setting for the current session is the set of configurations that are operating while the camera is currently running, including all unsaved changes you have made to the settings before saving them.

These active settings are stored in the camera's *volatile* memory and will be lost and cannot be restored if the camera resets or if the camera is powered down or loses power.

To save these settings for reuse the next time you power up or reset the camera, or to protect against losing them in the case of power loss, you must save the current settings using the **User Set Save** parameter. Once saved, the current settings become the selected **User Set**.

User Setting

The user setting is the saved set of camera configurations that you can customize, resave, and restore. By default the user settings are shipped with the same settings as the factory set.

The command **User Set Save** saves the current settings to non-volatile memory as a **User Set**. The camera automatically restores the last saved user settings when it powers up.

To restore the last saved user settings, select the **User Set** parameter you want to restore and then select the **User Set Load** parameter.

Factory Settings

The factory setting is the camera settings that were shipped with the camera and which loaded during the camera's first power-up. To load or restore the original factory settings, at any time, select the **Factory Setting** parameter and then select the **User Set Load** parameter.

Note: By default, the user settings are set to the factory settings.

Default Setting

Either the Factory or one of the User settings can be saved as the Default Setting by selecting the set in the User Set Default Selector. The chosen set automatically saves as the default setting and is the set loaded when the camera is reset of powered up.

Trigger Modes

The camera's image exposures are initiated by a trigger event. The trigger event is either a programmable internal signal used in free running mode, an external input used for synchronizing exposures to external triggers, or a programmed function call message by the controlling computer. These triggering modes are described below.

- Free running (trigger disabled): The camera free-running mode has a programmable internal timer for frame rate and a programmable exposure period.
- External trigger: Exposures are controlled by an external trigger signal. The external trigger signal can be either a Camera Link control line (i.e. CC [4 : 1]) or a general purpose input (e.g. GPIO [1 : 0]. General purpose inputs are isolated by an opto-coupler input with a time programmable debounce circuit.
- Software trigger: An exposure trigger is sent as a control command via the Camera Link serial communications interface.
- Software triggers cannot be considered time accurate due to communications latency and sequential command jitter.

Exposure Controls

Exposure Control modes define the method and timing of how to control the sensor integration period. The integration period is the amount of time the sensor is exposed to incoming light before the video frame data is transmitted to the controlling computer.

- Exposure control is defined as the start of exposure and exposure duration.
- The start of exposure can be an internal timer signal (free-running mode), an external trigger signal, or a software function call trigger.
- The exposure duration can be programmable (such as the case of an internal timer) or controlled by the external trigger pulse width.

The Falcon2 camera can grab images in one of three ways. You determine the three imaging modes using a combination of the Exposure Mode parameters (including I/ O parameters), Exposure Time and Frame Rate parameters.

Description	Frame Rate	Exposure Time	Trigger Source (Sync)
Internal frame rate and exposure time	Internal, programmable	Internal programmable	Internal
External frame rate and exposure time	Controlled by EXSYNC pulse	External (EXSYNC)	External
EXSYNC pulse controlling the frame rate. Programmed exposure time.	Controlled by EXSYNC pulse	Internal programmable	External

Figure 10. Exposure controls

The parameters used to select the imaging modes—trigger sources (sync), exposure time, and frame rate—are grouped together as the Sensor Controls.

Sensor Controls	
Frame Rate (in Hz)	Camera frame rate in Hz. Only available when the start frame trigger parameter is disabled (Trigger Mode off).
Exposure Mode	Set the operation mode for the camera's exposure. Trigger Width or Timed. Trigger Width is only available when Trigger Mode is enabled.
	Trigger Width Uses the width of the current Frame trigger signal pulse to control the exposure duration. Note, if the Frame TriggerActivation is LevelHigh, the exposure duration will be the time the trigger stays High. If TriggerActivation is LevelLow, the exposure time will last as long as the trigger stays Low. The TriggerWidth setting is applicable with the TriggerSelector feature set to Framestart.
	Timed The exposure duration time is set using the ExposureTime or ExposureTimeAuto features and the exposure starts with the FrameStart event.
Exposure Time	Sets the exposure time (in microseconds). Exposure Mode feature must be set to Timed

Exposure Modes in Detail

Internally Programmable Frame Rate and Internally Programmable Exposure Time (Default)

Frame rate is the dominant factor when adjusting the frame rate or exposure time. When setting the frame rate, exposure time will decrease, if necessary, to accommodate the new frame rate. When adjusting the exposure time the range is limited by the frame rate.

Note: The camera will not set frame periods shorter than the readout period.

GenICam parameters:
I / O Controls > Trigger Mode > Off

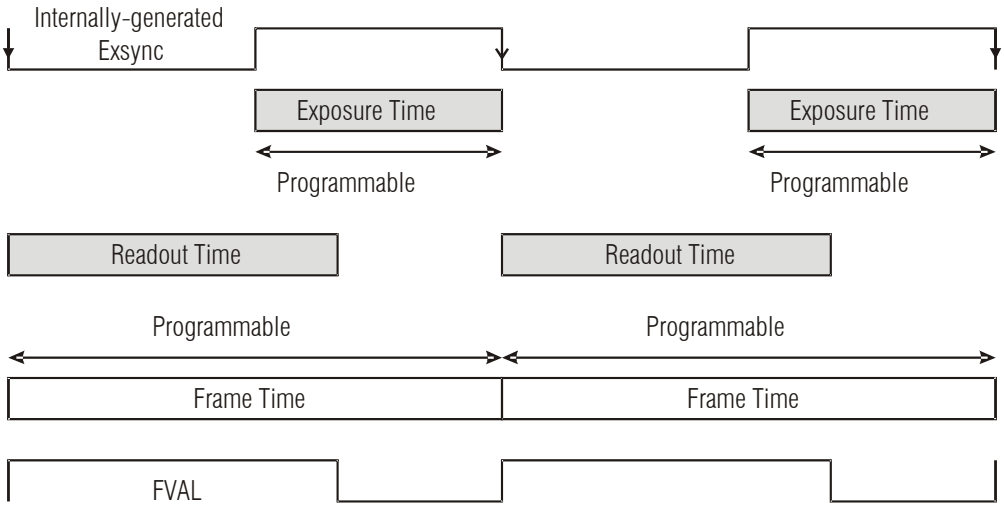


Figure 11. Internally Programmable Frame Rate and Internally Programmable Exposure Time (Default)

External Frame Rate and External Exposure Time (Trigger Width)

In this mode, EXSYNC sets both the frame period and the exposure time. The rising edge of EXSYNC marks the beginning of the exposure and the falling edge initiates readout.

GenICam parameters:
I / O Controls > Trigger Mode > On
Sensor Control > Exposure Mode > Trigger Width

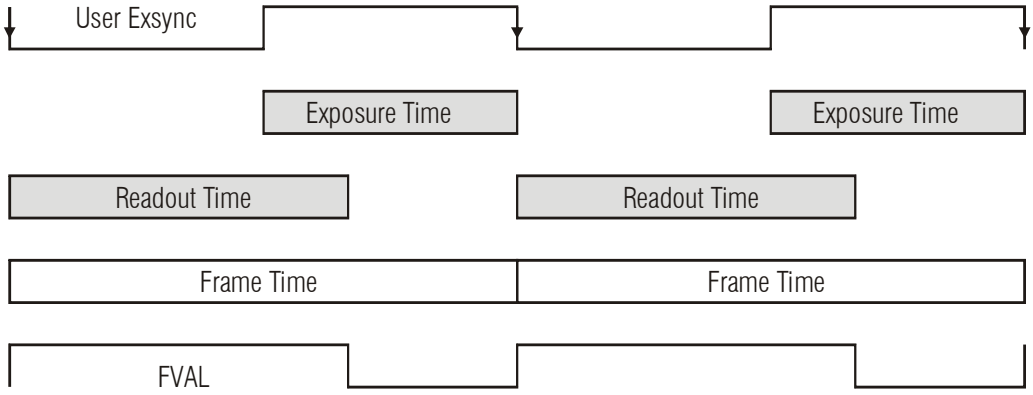


Figure 12. External Frame Rate and External Exposure Time (Trigger Width)

External Frame Rate, Programmable Exposure Time

In this mode, the frame rate is set externally with the falling edge of EXSYNC generating the rising edge of a programmable exposure time.

GenICam parameters:
I / O Controls > Trigger Mode > On
Sensor Control > Exposure Mode > Timed

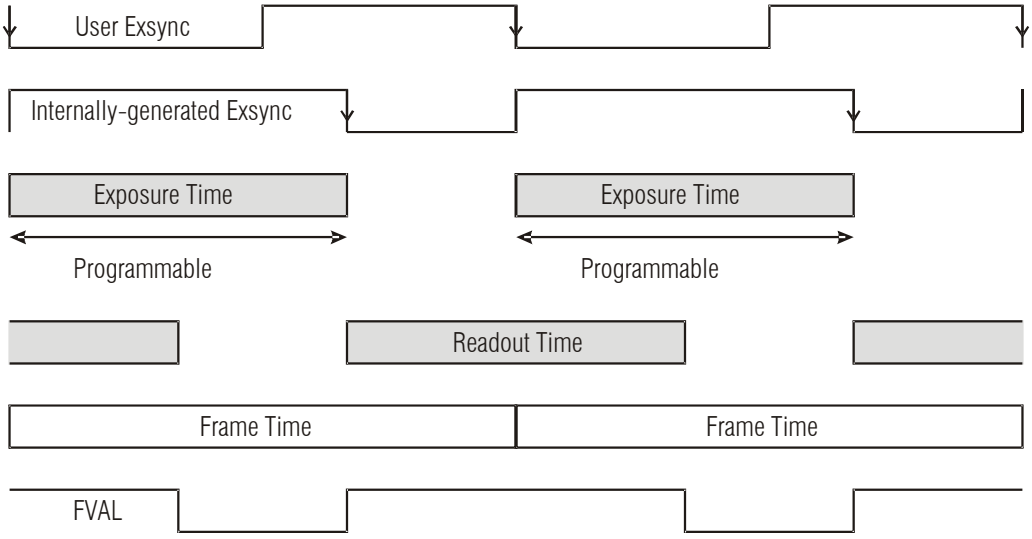


Figure 13. External Frame Rate, Programmable Exposure Time

Set Frame Rate

Sensor Control	
Parameter	**Options**
Frame Rate (in Hz)	Camera frame rate, in Hz. Only available when the camera is in Internal Mode—frame trigger is disabled (Trigger Mode off).

To set the camera's frame rate use the **Frame Rate parameter**, part of the Sensor Controls set. This command can only be used when the camera is in Internal mode—that is, when the start frame trigger is disabled (Trigger Mode Off).

Dependencies
The frame rate is dependent on the window size, and the exposure times are dependent on the frame rate. For example, decreasing the frame rate allows for a longer exposure time. To increase the frame rate decrease the window size. Frame rate takes priority over exposure time. Maximum exposure time can be increased by lowering frame rate.

Faster frame rates can be achieved using the width and height offset X and Y features.

The chart shows maximum camera speed in fps for different combinations of resolutions aspect ratios and sensor bit depths (input pixel size):

10 Taps

Resolution	Aspect Ratio	Maximum Column	Maximum Rows	Frame Rate (8 Bit Pixel Size)	Frame Rate (9 Bit Pixel Size)	Frame Rate (10 Bit Pixel Size)
12M	4:3	4096	3072	58	58	58
8M	1:1	2816	2816	90	89	66
8M	4:3	3328	2502	86	86	74
4M	1:1	2048	2048	148	122	91
4M	4:3	2432	1728	168	145	108

8 Taps

Resolution	Aspect Ratio	Maximum Column	Maximum Rows	Frame Rate (8 Bit Pixel Size)	Frame Rate (9 Bit Pixel Size)	Frame Rate (10 Bit Pixel Size)
12M	4:3	4096	3072	46	46	46
8M	1:1	2816	2816	75	74	57
8M	4:3	3328	2502	71	71	63
4M	1:1	2048	2048	137	122	91
4M	4:3	2432	1728	140	132	101

Set Exposure Time

To set the camera's exposure time, use the Exposure Time parameter—a member of the Sensor Controls set.

GenICam parameters:
Sensor Controls > Exposure Time (Timed Exposure Mode)

External Exposure Time: 20 μs (min) to 1 second (max).
Internal Exposure Time: (1 / frame rate) – 24 μs.

Note: The maximum exposure time is dependent on the frame rate. To increase maximum exposure time, decrease the frame rate.

Hot Pixels and Long Exposure Times

The Falcon2 camera is calibrated and optimized for an exposure time of 1500 micro seconds providing peak FPN and PRNU performance are at this setting. This FPN correction also manages hot pixels for the same exposure time. Changing the exposure time to very long times such as 60000 micro-seconds can introduce additional uncorrected hot pixels in the image. The user can eliminate these pixels if they want long exposure times by doing a user FPN correction which will capture and correct these pixels. This correction would be optimized for the long exposure time and would show higher FPN for lower exposure times. The Falcon2 camera uses defective pixel concealment as part of the calibration routine which automatically interpolates over defective un-correctable pixels when FPN correction is enabled.

Input / Output Control

CamExpert combines the camera I / O Controls Parameters into one group. These parameters allow configuring the Falcon2 inputs and outputs for type of signal and signal polarity.

The Falcon2 cameras offer great flexibility when configuring your camera output, such as determining the camera's Camera Link configuration, number of output taps, and bit depth, and output (pixel) rate. These commands work together to determine your final camera output configuration.

I / O Controls		
Action	**Parameter**	**Description**
Select / enable the trigger to configure	Trigger Selector	Set to Frame Start or Frame Burst Start.
Enable or disable the selected trigger	Trigger Mode	On Off -Only one "tow" trigger can be active at a time. Enabling one trigger will automatically disable any active ones.
Specify the internal signal or input line to use as the trigger source	Trigger Source	-CC1 / CC2 / CC3 / CC4 -Line 1 -Line 2 The selected trigger source must have its Trigger Mode set to On.
Use a software command (internal) as a trigger source	Trigger Software	Disabled when trigger source is Frame Start.

		Enables the software trigger button.
Specify the type of trigger overlap permitted with the previous frame. This defines when a valid trigger will be accepted (or latched) for a new frame	Trigger Overlap	
Specifies the delay in microseconds (µs) to apply after the trigger reception before activating it	Trigger Delay	The delay of the selected trigger in 1 µs increments.
Select the logical line of the device to configure.	Line Selector	-CC1 / CC2 / CC3 / CC4 (Inputs) -Line 1 (Input) -Line 2 (Input) -Line 3 (Output) -Line 4 (Output)
Read the pin associated with the logical line	Line Name	Input 1 / 2 / 3 / 4 / 5/ 6.
The physical pin location associate with the logical line.	Line Pin Association	Read Only.
Specify the voltage threshold required to recognize a signal transition on an input line.	Line Detection Level	Threshold_2_4 (2.4V) Threshold_6_0 (6V) Threshold_12_0 (12V)
Specify if the selected pin is used as an input or output signal	Line Mode	-Input (CC1 to CC4, Line 1 and Line 2) -Ouput (Line 3 and Line 4) Read Only.
Set the polarity of the line, whether to invert the selected input or output line signal	Line Inverter	Polarity On Polarity Off
Read the current status of the selected input or output line	Line Status	
Specify the minimum length of an input line voltage transition before recognizing a signal transition.	Line Debouncing Period (µs)	Min 1 µs, Max 255 µs.
Returns the current status of all available line signals, at time of polling, in a single bit field.	Line Status All	The order is Line1, Line2, Line3, Line4, CC1, CC2, …
Select which internal signal, event driven pulse or software control state to output on the selected line. Note: the Line Mode feature must be set to Output.	Output Line Source	Off SoftwareControlled PulseOnStartofExposure PulseOnEndofExposure PulseOnStartofReadout PulseOnEndofReadout PulseOnInput1 PulseOnInput2 PulseOnInput3 PulseOnInput4 PulseOnInput5 PulseOnInput6
Sets the delay before the output line pulse duration is output. Applicable for the Output Line Source feature. Note: the Line Mode feature must be set	Output Line Pulse Delay	Min 0 µs, Max 8388608 µs

to output.		
Sets the width (duration) of the output line pulse in microseconds (µs). The Line Mode feature must be set to Output.	Output Line Pulse Duration	Min 0 µs, Max 8388608 µs
Output Line that are currently in Software Latch control will only set with the value in Output Line Value with the Output Line Software Command feature	Output Line Software Latch Control	Off, changes to the output line value are applied immediately. On, changes to the output line value are applied when the Output Line Software Command is triggered.
Selects the state of the output on the selected line. The Line Mode feature must be set to Output and the Output Line Source feature must be set to Software Controlled. The Value will be applied immediately if the Output Line Software Latch Control feature is equal to OFF.	Output Line Value	-Active -Inactive
Output Line Software Command	Output Line Software Command	

Control Gain and Black Level

The Falcon2 cameras provide gain and black level adjustments in the digital domain for the CMOS sensor. The gain and black level controls can make small compensations to the acquisition in situations where lighting varies and the lens iris cannot be easily adjusted. The user can evaluate gain and black level by using CamExpert.

The parameters that control gain and black level are grouped together in the Sensor Controls set.

Sensor Controls	
Parameter	**Description**
Gain Selector	Select the channel to control the gain for All digital channels of taps
Gain	Set the gain as an amplification factor applied to the video signal 0 to 8x.
Black Level Selector	Adjust the black level All digital channels or taps
Black Level	Apply a digital subtract before FPN correction. -200 to 800 DN (10 bit).

Image Size

To set the height of the image, and therefore the number of lines to scan, use the parameters grouped under the Image Format Control set.

Image Format Control		
Action	**Parameter**	**Description**
Control the size of the transmitted image		
	Width	Width of the image / area of interest (in pixels)
	Height	Height of the image in lines
	Offset X	Left coordinate of region of interest. Horizontal offset of the leftmost pixel relative to the active sensor area.
	Offset Y	Vertical offset in lines of the uppermost pixel relative to the active sensor area.
	Pixel Format	Mono 8 or Mono 10, bit depth to Camera Link
	Pixel Color Filter	Type of color filter applied to the image
	Pixel Coding	Coding of the image pixels. Raw data is the native format of the sensor.
	Pixel Size	Bit depth to Camera Link
Action	**Parameter**	**Description**
Select an internal test image	Test Image Selector	Grey Horizontal Ramp Grey Vertical Ramp Purity Diagonal Ramp FPN Diagonal Ramp PRNU Sensor Static Pattern1 Sensor Dynamic Pattern1 Static Value FPN Coefficients
Action	**Description**	
Define multiple areas of interest (AOIs)	Preliminary feature. See Appendix A for more information.	

Set Baud Rate

The baud rate sets the speed (in bits per second—bps) of the serial communication port and is available as part of the Serial Port Control parameters.

Serial Port Control		
Action	**Parameter**	**Description**
Control the baud rate used by the camera's serial port	Baud Rate	9600 19200 57600 115200 230400 460800

Number of bits per character used in the serial port	Data Size	
Parity of the serial port	Parity	
Number of stop bits per character used in the serial port	Number of Stop Bits	

I / O Opto-couplers

Falson2 provides two sets of Opto-isolated input signals. These can be used as external trigger sources. The signals should be in range from 2.4 V to 24 V, 5 V typical, 2 mA min.

The delay between signals at the I / O pin and the internal timing core is a function of the signal swing and the typical latency @5V swing is 6.5 µs.

Note that the outputs are a powerless device and require external power.

Refer to the 12-Pin Hirose Power Connector signal details (page 17) for the connector pin out and electrical information. The cable shell and shield should electrically connect the camera chassis to the computer chassis for maximum EMI protection.

Each input incorporates a signal debounce circuit (following the opto-coupler) to eliminate short noise transitions that could incorrectly be interpreted as a valid pulse. The duration is user programmable from 0 µs to 255 µs with CamExpert.

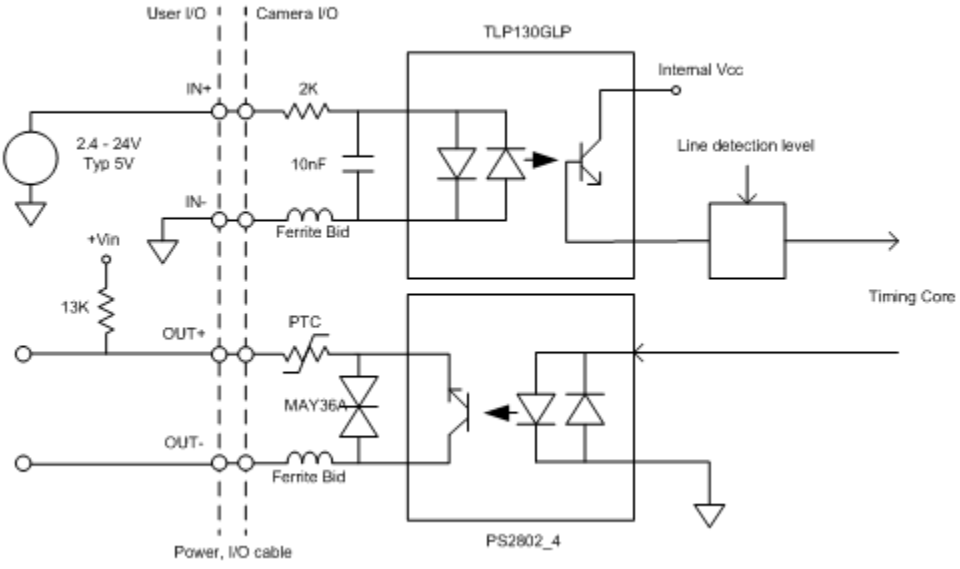


Figure 14. I / O Optocoupler Diagram

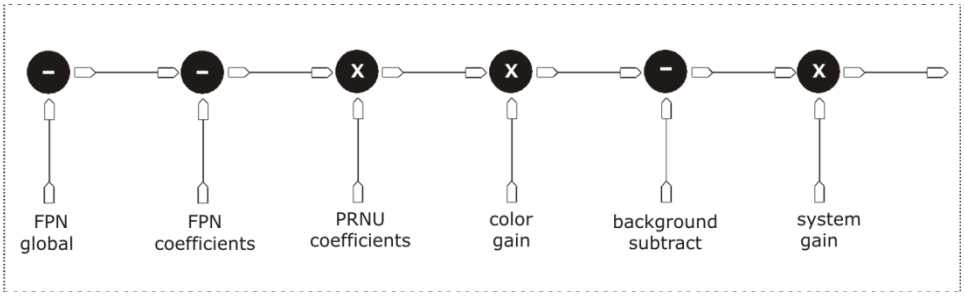
Calibrating the Camera: Flat Field Correction

Note: FFC calibration can only be performed on the full window (4 : 3 and 1 :1 aspect ratios).

This camera has the ability to calculate correction coefficients in order to remove non-uniformity in the image. This video correction operates on a pixel-by-pixel basis and implements a two point correction for each pixel. This correction can reduce or eliminate image distortion caused by the following factors:

- Fixed Pattern Noise (FPN)
- Photo Response Non Uniformity (PRNU)
- Lens and light source non-uniformity

Correction is implemented as follows:



$$V_{output} = [(V_{input} - \text{FPN (per pixel)} - \text{global FPN}) * \text{PRNU (per pixel)} - \text{Background Subtract}] \times \text{System Gain}$$

where	V_{output}	=	digital output pixel value
	V_{input}	=	digital input pixel value from the sensor
	PRNU(pixel)	=	PRNU correction coefficient per pixel
	FPN(pixel)	=	FPN correction coefficient per pixel
	Background Subtract	=	background subtract value
	System Gain	=	digital gain value

The algorithm is performed in two steps. The fixed offset (FPN) is determined first by performing an averaging without any light. This calibration determines exactly how much offset to subtract per pixel in order to obtain flat output when the sensor is not exposed.

The white light (PRNU) calibration is performed next to determine the multiplication factors required to bring each pixel to the required value (target) for flat, white output.

It is important to do the FPN correction first. Results of the FPN correction are used in the PRNU procedure. We recommend that you repeat the correction when a temperature change greater than 10 °C occurs.

GenICam Parameters

Feature	Sensor Control Menu Item >	Parameter
FPN Global	Black Level Selector	Digital ALL1
Background Subtract	Black Level Selector	Digital ALL2
System Gain	Gain Selector	Digital ALL

PRNU correction requires a clean, white reference. The quality of this reference is important for proper calibration. White paper is often not sufficient because the grain in the white paper will distort the correction. White plastic or white ceramic will lead to better balancing.

For best results, ensure that:

1. Ambient light flicker (e.g. fluorescent lights) is sufficiently low not to affect camera performance and calibration results.
2. The average pixel should be at least 20% below the target output. If the target is too close, then some pixels may not be able to reach full swing due to correction applied by the camera.
3. When 6.25 % of pixels from a single row within the region of interest are clipped, flat field correction results may be inaccurate.
4. Correction results are valid only for the current black offset values. If you change this value, it is recommended that you recalculate your coefficients.

Let's go through a flat field calibration example:

1. The camera is placed in **full internal exposure and frame rate** (no other exposure mode will allow FFC calibration).
2. Settings such as frame rate, exposure time, etc. are set as close as possible to the actual operating conditions. Set **system gain to 1** and **background subtract to 0**, as these are the defaults during FFC calibration.
3. Select **correction active set to user flat field 1**. Go to **flat field correction mode,** select **calibration**.
4. Clear existing coefficients by pressing flat field calibration, clear coefficient.
5. Place the camera in the dark and press **FPN calibration**, this performs the FPN correction and saves the FPN coefficients to non-volatile memory.
6. Calibration mode enables both FPN and PRNU correction. Verify signal output is close to 0 DN.
7. Illuminate the sensor to 65 % saturation and set **flat field target** to 80 % saturation.
8. Press **PRNU calibration**.
9. **Save** the flat field calibration.

Here is the factory calibration procedure for the 8M camera:

1. The camera is placed in full internal, 8 taps, 10 bits, active window (3328 x 2816, only available to factory), system gain 1, background subtract 0, global FPN calibrated such that dark FPN is 30 DN (10 bit) 50 fps, 1500 µs exposure. This last part is important (50 fps, 1500 µs exposure) and ensures that the camera is in non-concurrent mode. In non-concurrent mode, readout and integration do not overlap thus eliminating some residual artifacts.

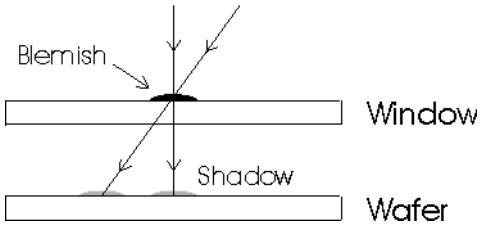
2. The camera is placed in the dark and **FPN** Calibration is run.
3. With FPN correction on the sensor is illuminated (Light Source: Broadband Quartz Halogen, 3250 K, with a 750 nm cutoff filter) with a light level of 26.4 µW/ cm^2 (10 BPP). This ensures each camera will have the same responsivity since the light level and target value are always the same. Typical output levels for the camera at this light level are 680 DN (10 bit).
4. The sensor window at this point has been cleaned thoroughly such that there are no significant blemishes present.
5. Send **PRNU at a target of 840 DN (82.11 % peak)**.

How can one match gain and offset values on multiple cameras?

One way is of course to use flat field correction. All cameras would be set up under the same conditions including lighting and then calibrated with FPN and PRNU. This can be time-consuming and complicated (especially the white target). Another way is to use global FPN (Sensor Control > Black Level Selector > DigitalAll1):

1. Starting from factory settings (factory flat field), take note what the highest dark offset is among the set of cameras. If the highest dark offset is higher than about 16 DN (10 bit) you might want to consider recalibrating the FPN correction. Large differences in dark offset between the factory and user are typically caused by differences in temperature from factory to user. Large dark offsets will result in PRNU-correction-induced FPN and should therefore be avoided.
2. Decrease global FPN (increase the offset in dark) on all cameras until they are the same and reach at least 4 DN (10 bit).
3. Illuminate to about 80 % saturation (820 DN, 10 bit) and note the highest signal level among the set of cameras.
4. Increase the system gain (Sensor Control > Gain Selector > DigitalAll1) on the cameras until they all reach the same output level (highest of all cameras).
5. Place camera in the dark and repeat step 2 to 4 until both dark offset and 80 % sat signal levels are equal on all cameras.

An important note on window blemishes:
When flat field correction is performed, window cleanliness is paramount. The figure below shows an example of what can happen if a blemish is present on the sensor window when flat field correction is performed. The blemish will cast a shadow on the wafer. FFC will compensate for this shadow by increasing the gain. Essentially FFC will create a white spot to compensate for the dark spot (shadow). As long as the angle of the incident light remains unchanged then FFC works well. However when the angle of incidence changes significantly (i.e. when a lens is added) then the shadow will shift and FFC will makes things worse by not correcting the new shadow (dark spot) and overcorrecting where the shadow used to be (white spot). While the dark spot can be potentially cleaned, the white spot is an FFC artifact that can only be corrected by another FFC calibration.



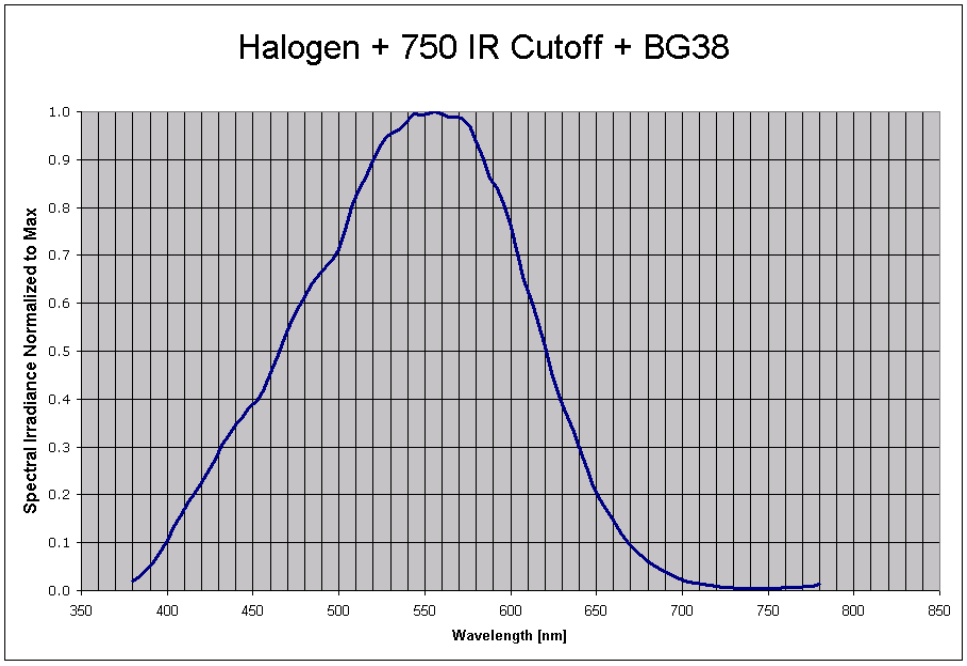


Figure 15: Spectral distribution of light source used during calibration of color cameras only. This corresponds roughly to a 5200 K color temperature.

File Access Control

Use the File Access Control features to upload (firmware, FFC coefficient files) and download (FFC coefficient files, error log files) to and from the camera.

File Access Control	
Feature	**Description**
Firmware	Upload firmware files to the camera.
FFC Coefficients 1 to 4	Upload or download selected FFC coefficient files.
Error Log Files	Download error log files from the camera.

Appendix A

Defining Multiple Areas of Interest

Note: This feature is preliminary.

Use the **Multiple AOI commands** to define multiple areas of interest. Once defined, each of the AOIs share a common width and x-offset value. That is, all the allowable windows you define will have the same pixel width and the same starting coordinate (x-offset value). Within these defined parameters you are free to set the height and y-offset values, including overlapping height values. Up to 16 windows are permitted. The maximum frame rate will be dependent on the total size of the selected AOIs.

To specify multiple areas of interest:

GenICam parameters > Image Format Controls:

1. Set the **Multiple AOI Mode > Active.**
2. In the **Multiple AOI Count >** set to the total number of windows you want (minimum of 2, maximum of 16).
3. Select one of the AOIs from Step 2 to define, using the **Multiple AOI Selector**.
4. Set the Width and Height of the selected AOI, using the **Multiple AOI Width and Height parameters**.
5. Set the Offset X and Offset Y values of the select AOI, using the **Multiple AOI Offset X and Offset Y parameters**.
6. Choose another AOI to define, using the **Multiple AOI Selector**
7. Repeat Steps 4 to 6 for each AOI. Note: the Width and the Offset X parameters are constant for each AOI. Changing them for one of the select AOIs will automatically change them for the others in the set.

Image Format Control		
Action	**Parameter**	**Description**
Enable the Multiple AOI (Area of Interest).	Multiple AOI Mode	Active Off
Specify the number of AOIs you want to define.	Multiple AOI Count	Min 2, Max 16.
Select one of the AOIs to define.	Multiple AOI Selector	
Set the width of the selected AOI (in pixels).	Multiple AOI Width	
Set height of the selected AOI (in pixels).	Multiple AOI Height	
Set horizontal offset from the origin to the selected AOI.	Multiple AOI Offset X	
Set vertical offset, in pixels, from the origin to the selected AOI (in pixels).	AOI Offset Y	

Revision History

Revision Number	Change Description	Revision Date
00	Initial (Preliminary) release	11-Nov-11
01	Extensive revisions made throughout the manual in preparation for camera production and general release.	03-Feb-12

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